Исследование выполнено при финансовой поддержке РФФИ в рамках научного проекта № 16-32-00327 мол_а

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RESEARCH OF DIELECTRIC CONSTANT OF MATERIALS USED IN THE ARCTIC

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The Arctic is of fundamental military-strategic importance for Russia. The development of the Arctic without an advanced telecommunication infrastructure is very difficult. To supply working in the Arctic employees with universal means of communication it is the most efficient to use wireless communication band between 2.4 GHz and 5 GHz. Facilities, where radio telecommunication equipment in the Arctic works, have walls consisting of a multilayer structure. There is the problem of organizing optimal communication. The most effective way is the organization with the application of MIMO technology [1]. To use this theory it is necessary to know the complex value ε that is the dielectric constant of a particular material.

The most optimal method to study the dielectric properties of materials is the use of the waveguide method of short circuit and idle [2]. The method is based on the searching for the standing wave ratio (SWR) and the phase of the microwave signal transmitted through the sample.

After calibrating, waveguide section with the sample is set into microwave section. It leads to a shift in the standing wave minimum, which depends on the properties of the researched dielectric and connected with its electrical characteristics by correlation, obtained by solving the corresponding electrodynamic task leading to complex transcendental equation. Escaping its solvation is possible by means of the waveguide method of short circuit and idle. [4] This method gives good results and involves measuring the SWR and displacement of the standing wave minimum relative to the reference plane chosen for the sample at the end of which short circuit and idle modes are created alternatively. Omitting conclusion, we present only the final form of the formulas for the calculation of the real and imaginary parts of the complex permittivity ε' and ε'':

$$\varepsilon' = \frac{AC + BD}{A^2 + B^2} \cdot \left\{1 - \left(\frac{\lambda_0}{2a}\right)^2\right\} + \left(\frac{\lambda_0}{2a}\right)^2 \tag{1}$$

$$\varepsilon'' = \frac{BC - AD}{A^2 + B^2} \cdot \left\{1 - \left(\frac{\lambda_0}{2a}\right)^2\right\}, \tag{2}$$

where

$A = 1 - S_1 S_2 tg(\beta\Delta x_1) tg(\beta\Delta x_2)$, $B = S_1 tg(\beta\Delta x_1) + S_2 tg(\beta\Delta x_2)$, $C = S_1 S_2 - tg(\beta\Delta x_1) tg(\beta\Delta x_2)$, $D = S_1 tg(\beta\Delta x_2) \cdot S_2 tg(\beta\Delta x_1)$, S_1, S_2 – SWR in modes of short circuit and idle respectively;

$\beta = \frac{2\pi}{\lambda_w}$ – propagation constant in air-filled waveguide (λ_w – wave length in waveguide);

$\Delta x_1, \Delta x_2$ – displacement of the standing wave minimum relative to the reference plane chosen for the sample at the end of which short circuit and idle respectively; in case of «half-infinite» layer $\Delta x_1 = \Delta x_2$ and $S_1 = S_2$;

λ_0 – wave length in free-space;

$2a = \lambda_{cr}$ – critical wave length, where a – waveguide width (the biggest side of cross-section).

A block diagram of the measuring stand we proposed is shown in Figure 1. The stand includes a signal generator 1 (G4-79 (1,78-2,56 GHz) or G4-81 (4-5.6 GHz)), ferrite valve 2, which provides isolation ~ 20 dB, attenuator 3, the waveguide measuring line 4, selective voltmeter 5, waveguide section with the sample 6 at the end of which the piston 7 a short circuit and an idling mode may alternatively be created. Voltage SWR of such shorting plug is not worse than 30. Absolute measurement error of ε′ does not exceed 0.5. Produced measurements allowed us to get ε′ and ε′′ for a variety of materials used indoor.

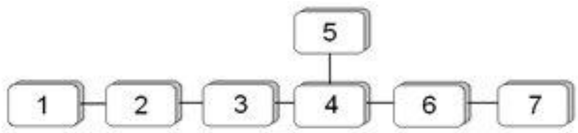

Fig. 1. A block diagram of a measuring stands to study complex dielectric permittivity.

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